Identifying the Population Sources of Alcohol Impaired Driving: An Assessment of Context Specific Drinking Risks

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ABSTRACT. Objective: High-risk drinkers who drink in high-risk contexts like bars are recognized as a primary source of alcohol-impaired drivers and motor vehicle crashes within communities. We assess the contributions of drinking in other contexts to these outcomes. **Method:** Self-report survey data from 8,553 adults in 50 California cities were used to estimate rates of driving after drinking (DAD; driving within 4 hours of drinking any alcohol) and a measure of alcohol-impaired driving (AID; driving when having had "too much" to safely drive home) associated with drinking in bars, homes, restaurants, parties, and other contexts. **Results:** Frequent drinking (b = .0588, z = 2.17, p = .030) and drinking outside the home, $\chi^2(4) = 74.46$, $p < .001$, at bars (b = .1418, z = 1.97, p = .049), and at restaurants (b = .2694, z = 5.60, $p < .001$) were related to greater DAD; lower risks were associated with drinking at home (b = -.0607, z = -2.16, p = .031). AID frequency was directly proportional to DAD (b = .0863, z = 8.43, $p < .001$) with no differences observed across contexts. Within a community of 100,000 persons over 6 months, 879 AID events were attributed to drinking at 102 restaurants and 726 AID events to drinking at 15 bars. **Conclusions:** Drinking at bars and restaurants contributes about equally to DAD and AID, with AID events concentrated in small populations that frequent relatively few bars and broadly distributed across large populations that frequent many restaurants. High frequencies of drinking at home were also associated with surprisingly large numbers of DAD and AID events. Observed differences between individual and community risks for DAD and AID must be addressed in place-based community prevention programs. (*J. Stud. Alcohol Drugs, 79,* 702–709, 2018)

THE INCIDENCE OF alcohol-impaired driving (AID) in U.S. communities will be affected by frequent drinking in contexts that entail driving (e.g., bars) and personal characteristics of drinkers associated with the choice to drive after drinking (e.g., poor impulse control). Consequently, moderate levels of alcohol use outside the home, if of sufficient frequency and associated with some risk for driving after drinking "too much" to drive safely, may lead to substantial numbers of impaired driving events. Thus, among a small group of 100 drinkers who drive after drinking outside the home an average of 5 times each month, and who each have a probability of impaired driving of 0.01 on each occasion, there will be a 0.997 chance of impaired driving occurring at least once. For this reason, although much of the research literature on AID has focused on heavy drinkers and repeat drunken drivers, it is possible that another substantial source of AID events may be frequent drinkers who occasionally drive after drinking and sometimes drink "too much" to drive safely. As an instance of the prevention paradox (Kreitman, 1986; Rose, 1981), such events would be rare for any individual drinker but frequent among large populations of drinkers, broadly distributed across the drinking population, and difficult to detect and control through enforcement efforts. Survey research methods can be used to detect populations of drinkers who occasionally drive after drinking (DAD) and contribute to the incidence and prevalence of AID. These methods allow us to link alcohol use in different contexts to greater risks for problems among drinking drivers (Wieczorek et al., 1992). Through the identification of community contexts associated with greater AID risks we can target community prevention efforts to reduce AID (Gruenewald et al., 2016a).

A large research literature has examined the demographic, social, and cognitive characteristics of drinking drivers that lead to DAD and AID and assessed key aspects of physical, policy, and enforcement environments that may reduce these problems (Cook, 2007). This literature is fairly consistent in the identification of persons most at risk for drunken driving. Demographic characteristics include income, marital status, gender, ethnic group membership, and age, with younger drivers at substantially greater risk. Critical cognitive-social correlates include impulsivity, tolerance of deviance, risk taking, and membership in peer networks with other high-risk drinkers (Bingham et al., 2007; Dick et al., 2010; Greenberg et al., 2005). It also appears that drinking in high-risk contexts like bars or parties may impair decision processes and aggravate problems related to drinking in those contexts (Burian et al., 2002; Steele & Josephs, 1990; Vuchinich & Heather, 2003; Zawacki, 2002). However, despite the obvious importance of drinking contexts to risks for DAD and AID, there has been little research examining the ecological circumstances that enable these behaviors. Drinking places, like bars and restaurants, may be regulated to reduce problems and are often the targets of environmental preventive interventions (Gruenewald et al., 2016a). Consequently, one critical ecological task in community assessments of alcohol-impaired driving should be to establish the distribution of

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these drinking events across drinking places. Although a growing body of literature now focuses on drinking places and associated drinking risks, this work has not been extended to assessments in the general population (Homel & Graham, 2008; Mäkelä et al., 2016). Studies of the use of drinking contexts provide the ecological link between individual patterns of use and population rates of alcohol problems.

A small body of early research has demonstrated that such assessments are possible, that characteristics of drinkers and drinking can be related to drinking places (Gruenewald et al., 1993, 2002; Single & Wortley, 1993; Treno et al., 2000), and that social interactions in those places can accelerate drinking problems (Caudill & Marlatt, 1975; Collins et al., 1985; Kuendig & Kuntsche, 2012). A recent assessment of correlates of the use of drinking places among representative samples of adults from 50 California cities showed that the most to least frequently used places were one's own home, relatives' or friends' homes, restaurants, bars, and parties (Gruenewald et al., 2013). Drinking in bars was associated with less frequent but much heavier drinking and four high-risk cognitive-social characteristics: impulsivity, tolerance of deviance, risky driving, and membership in peer networks with other drinking drivers. Drinking at parties was related to less frequent drinking, impulsivity, and risky driving. Drinking in restaurants was associated with less frequent drinking and risky driving. Drinking at home was associated with more frequent drinking but no other risk characteristics. Thus, a bundle of high-risk cognitive-social characteristics related to drinking and impaired driving was observed among those drinkers frequenting bars, but other risk characteristics were also associated with the use of restaurants (risky driving) and drinking at home (high frequencies of use). In this article we extend this research to examine how cognitive-social characteristics of drinkers and drinking in these contexts are related to self-reported DAD and AID.

The primary questions to be addressed are (a) to what degree are different drinking contexts related to individual risks for DAD and AID, (b) what cognitive-social characteristics and drinking patterns are associated with these behaviors, and (c) how are risks related to drinking contexts distributed across populations in a representative community? From a prevention perspective, if correlates of the selection of drinking contexts predominate in the explanation of drinking and drunken driving, then prevention programs should be designed to ameliorate these context-specific risks. We test two hypotheses: (a) Each occasion of drinking outside the home (especially at bars) will have a stronger relationship to DAD than any drinking occasion at home; this reflects the concentration of at-risk drinkers in on-premise places and the likelihood of driving to these locations. (b) Despite the lower probability of DAD and AID following each drinking occasion at home, higher frequencies of drinking at home will result in considerable population-level risks related to this context.

Method

We conducted a general population telephone survey of adults 18 years of age and older across 50 randomly selected, non-adjacent cities in California with populations between 50,000 and 500,000 persons (N = 8,553). These were selected from all 138 cities of this size and covered all geographic areas of the state, excluding the City of Los Angeles and the combined city/county area of San Francisco (Gruenewald et al., 2013). Post-stratification weights based on each city's race/ethnicity, gender, and age distributions were constructed to increase generalizability to all 138 cities.

Data were collected using computer-assisted telephone interviews with respondents selected from list-assisted address and telephone numbers from January 1, 2009, to March 14, 2010. Although random-digit-dialing techniques are preferred, these are no longer feasible for targeted samples in California (Brick et al., 1995; Kempf & Remington, 2007; Tucker et al., 2002). Potential respondents were sent a preannouncement letter describing the study and allowed to opt out of the survey whenever they wished. Each household was screened for eligible respondents (men and women 18 years of age and older) and one respondent selected based on nearest birthdate. Surveys took about 30 minutes to complete and were conducted in English or Spanish. Respondents gave verbal consent to participate and received no remuneration. The survey response rate was 72.8% using standard definitions of the American Association of Public Opinion Research (2002). In all, 4,650 respondents (54.4%) reported drinking at some time in the past year and 1,892 of those (40.7%) reported having driven within 4 hours of drinking in the past 6 months.

Primary dependent measures were self-reported 6-month frequencies of driving within 4 hours of having had one or more drinks of beer, wine, or distilled spirits (DAD; "How often have you driven within 4 hours of drinking alcohol in the past 6 months?") and incidence among these drinkers of having driven after having had "too much" to drive safely (AID; "How often have you driven when you think you had "too much" to drive safely?"); the quotes emphasize that respondents determined their own level of safety in this regard. These items were selected from a set of four, which also queried driving "after having had anything to drink" and "within 1 hour of drinking," analyses of which essentially replicated those of the DAD and AID items used here (not presented). Although underreporting is a problem with these self-reports (Sawyer Sommers et al., 2002), these and similar self-report items have demonstrated good to excellent internal and test–retest reliability (Hettema et al., 2008).

Drinking measures were derived from self-reported frequencies of drinking 1, 2, 3, 6, or 9 or more drinks and

maximum drinks consumed over the previous 28 days (for frequent drinkers) or 12 months (for those who drank in the past year but not the past month). The question frame for these items was, "On how many days have you consumed X or more drinks of alcohol over the 'past 28 days' or 'past year'." Responses to these items were fit using a log-logistic continued drinking model (fit $R^2 > .95$ for 98% of respondents) that allows us to estimate average drinking quantities and volumes with good reliability and validity (test–retest reliabilities in the range $.65 < r < .85$; Gruenewald & Johnson, 2006). Drinking frequencies, average quantities consumed per occasion, and continued volumes (the number of drinks consumed beyond the first drink across occasions) were rescaled to 6 months to match the time frame of DAD and AID. Finally, frequencies of drinking at home, bars, restaurants, parties, and other places were assessed over 28 days or the past year (again conditional upon drinking in the past month) using techniques developed and validated in prior work and rescaled to a 6-month time frame (Treno et al., 2000). The question frame for these items was, "How often have you consumed alcohol at a <context> over the "past 28 days" or "past year." (We describe data on drinking in other places but exclude the measure from subsequent analysis to reduce collinearity.)

Cognitive-social measures included assessments of impulse control (Dickman Dysfunctional Impulsivity Scale, Dickman, 1990; Cronbach's $\alpha = .73$), tolerance of deviance and risky driving (Donovan, 1993; $\alpha = .78$ and $\alpha = .75$ respectively), and a measure of engagement in friendship networks with other drinking drivers (Gruenewald et al., 2013; $\alpha = .75$), each mean centered and *z*-score scaled. Four items assessed whether each respondent had friends who were known to drive after drinking, drive when having had too much to drink, or have been arrested or convicted for driving while intoxicated. Although effects related to these measures are important on their own merits, they also provided statistical control for confounding due to correlations of self-report outcomes with these personal characteristics.

Demographic measures were effects coded (+1 to -1) and included gender (coded for males), age groups (ages 30–45, 46–59, and ≥60 vs. age 18–29), ethnic group (Black, White, and Asian vs. other, with Hispanics independently coded), educational level (college or professional school graduate vs. high school or less), employment (full time and unemployed vs. part time), income ($20,000–$60,000, $61,000–$100,000, >$100,000 vs. <$20,000), marital status (married, separated/divorced/widowed vs. single), and immigrant status (born outside vs. within the United States).

Heteroscedasticity corrected censored regression analyses using sandwich estimators to correct for nesting of respondents within cities related these independent measures to (1) frequencies of DAD and (2), among those respondents, frequencies of AID (STATA tobithetm procedure; Shehata, 2011). Heteroscedasticity related to drinking patterns is a systematic source of bias in analyses of drinking problems, corrected here using quadratic effects for drinking frequencies and linear effects for drinking volumes (Gruenewald et al., 2016b).

Critical to these analyses is the quantitative treatment of relationships between drinking frequencies and frequencies of DAD and AID. Frequencies of DAD were assumed proportional to drinking frequencies, αF, with this proportion moderated by mixing ratios representing relative frequencies of use of contexts, f_i/F, $\alpha = a + b_i(f_i/F)$, so that $\alpha F = aF + b_i f_i$. Because more than one drinking place could be visited on any drinking day the sum of mixing ratios exceeded 1.00. By the same logic, frequencies of AID were assumed proportional to frequencies of DAD, with this proportion also moderated by mixing ratios representing relative frequencies of use of contexts. This procedure provides a critical control for variations in exposures to risks for DAD (due to frequencies of drinking) and AID (due to frequencies of driving after drinking), thus reducing the likelihood of observing spurious correlations related to exposure effects (a problem common to many statistical analyses of correlates of drinking and drunken driving).

The context-specific analyses of drinking and drunken driving also relied on a quantitative model that distinguished risks associated with drinking in contexts from risks related to heavier drinking in those contexts (Freisthler & Gruenewald, 2013; Mair et al., 2013). Parameters from the model reflect proportional increases in DAD or AID related to an additional occasion of use in a context (e.g., at a bar) and the average contribution of an additional drink consumed in that context (e.g., one additional drink at a bar, "dose-response"). This required the computation of expected average drinking quantities for each context by each drinker. Since average drinking quantities, Q, are weighted sums of average drinking levels, q_i, across contexts, f_i (i.e., weighted by context-specific drinking frequencies), these unobserved quantities were estimated by regressing average quantities over observed frequencies of use by contexts: $Q = k + q_1 f_1 + q_2 f_2 + q_3 f_3 + \ldots + q_n f_n + \varepsilon$; values related to missing contexts absorbed by the constant term. The q_i were treated as functions of exogenous terms, Zb_i, reflecting the impacts of demographic and psychosocial variables on use in contexts, and the model estimated to give relatively refined estimates of respondents' context-specific drinking levels (model R^2 of 0.673). Estimated average drinking quantities were 1.872 ± 0.024 drinks at home, 2.883 ± 0.040 drinks at bars, 1.384 ± 0.011 drinks at restaurants, 2.441 ± 0.043 drinks at parties, and 1.835 ± 0.033 in other places.

Results

Table 1 presents descriptive statistics for the primary variables used in the analyses. DAD was a relatively common event, occurring an average of 2.151 times over 6 months

TABLE 1. Descriptive statistics for primary measures (4,650 drinkers, weighted by population size; robust standard errors adjusted for clustering within 50 cities)

Measure	*M*	Robust *SE*
Drinking and driving prevalence (6 months)		
Driving within 4 hours of drinking (DAD, % of population)	34.426%	1.741%
Driving after having "too much" to drink (AID, % of population)	2.788%	3.850%
Drinking and driving incidence (frequencies, 6 months)		
Driving within 4 hours of drinking (DAD, events)	2.151	0.195
Driving after having "too much" to drink (AID, events)	0.028	0.004
Drinking measures (6 months)		
Frequency of use (F, days)	31.230	1.127
Average quantity consumed per occasion (Q, drinks)	1.950	0.049
Continued volume (V_c, drinks)	33.712	1.871
Frequencies of use of drinking places (6 months)		
Own home (F, days)	23.890	0.935
Bar or tavern (F, days)	1.661	0.178
Restaurant (F, days)	2.851	0.242
Party (F, days)	1.710	0.134
Other places (F, days)	2.793	0.112

among all drinkers (6.248 ± 0.598 times among 34% of drinkers who reported at least one DAD). AID was relatively uncommon, occurring an average of 0.028 times over 6 months among all drinkers (0.062 ± 0.011 times among 3% of drinkers who reported at least one AID event). Thus, the frequency of DAD events exceeded those of AID events by a factor of 76.8. The average drinker reported drinking about 5 times each month, having about 2 drinks on each occasion and drinking about 6 "continued" drinks for a total volume of 11 drinks each month ($F + V_c$, a total volume of about 65 drinks over 6 months). Finally, frequencies of drinking in one's own home exceeded the sum of all other drinking places (a factor of 2.7) and each drinking place (a factor of at least 8.4). Thus, any risk associated with drinking in the home would be amplified by excessive exposures to drinking in that context.

Table 2 presents Wald tests of the contribution of model components to analyses of rates of DAD and AID over 6 months. DAD varied significantly from one context to another ("Drinking Contexts") but were unrelated to heavier drinking ("Dose-Response"). Rates of AID were undifferentiated with respect to drinking contexts or heavier use. Cognitive-social and demographic measures were significant in both analyses.

Based on these Wald tests, reduced versions of each model are shown in Table 3. Drinking frequency was associated with DAD (columns 2–4) and DAD was associated with AID (columns 6–8); these exposures were strongly associated with elevated risks for DAD and AID. Each additional drinking occasion was associated with 0.0588 DAD events (1.84 DAD events at the average drinking frequency, column 5). Each additional DAD event was associated with 0.0863 AID events (0.54 AID events at the average DAD frequency).

Correcting for these exposures, drinking in the home was related to lower risks for DAD whereas drinking outside the home, regardless of context, was related to greater risks, Wald test, $\chi^2(4) = 74.46$, $p < .001$. Outside the home, greatest risks were associated with drinking in restaurants, less but not significantly so in bars (Restaurant-Bar $\Delta b = .1276$, $z = 1.47$, $p =$ N.S.), and least but not significantly so at parties (Bar-Party $\Delta b = .0611$, $z = 0.75$, $p =$ N.S.). Estimates of the rates of DAD events associated with average frequencies of use of each context were particularly informative, with a reduction of 1.44 DAD events associated with average frequencies of drinking at home versus +0.77 events associated with restaurants. Among cognitive-social measures only risky drinking was associated with greater DAD (one additional *z*-score unit associated with 0.53 more DAD events). Significant demographic correlates (not shown) included gender ($b = .306$, $z = 2.95$, $p = .003$; males having greater

TABLE 2. Wald tests of analysis components

		Driving within 4 hours of drinking (DAD) (n = 4,650)		Driving after drinking "too much" to drive safely (AID) (n = 1,892)	
Components	*df*	χ^2	*p*	χ^2	*p*
Drinking contexts	4	74.46	<.001	8.30	N.S.
Dose response	4	7.71	N.S.	5.64	N.S.
Cognitive social	4	36.06	<.001	14.18	.007
Demographics	18	92.90	<.001	54.01	<.001

Note: N.S. = not significant.

TABLE 3. Heteroskedastic censored regression models of 6-month frequencies of driving within 4 hours of drinking (n = 4,650) and driving after drinking "too much" to drive safely (n = 1,892)

	Driving within 4 hours of drinking (DAD)				Driving after drinking "too much" to drive safely (AID)			
Measures	*b*	*z*	*p**	*bX*[a]	*b*	*z*	*p**	*bX*[a]
Constant	-1.4758	-4.467	<.001	–	-7.5371	-5.52	<.001	–
Drinking frequency[b]	0.0588	2.17	.030	1.84	–	–	–	–
Driving after drinking[b]	–	–	–	–	0.0863	8.43	<.001	0.54
Drinking contexts (frequencies)								
Home	-0.0607	-2.16	.031	-1.44	–	–	–	–
Bar	0.1418	1.97	.049	0.56	–	–	–	–
Restaurant	0.2694	5.60	<.001	0.77	–	–	–	–
Party	0.0807	2.11	.035	0.14	–	–	–	–
Cognitive social								
Impulsivity	-0.1980	-1.70	N.S.	–	0.3083	1.42	N.S.	–
Tolerance of deviance	0.0482	0.60	N.S.	–	-0.2062	-0.57	N.S.	–
Risky driving	0.5288	6.05	<.001	–	0.0613	0.30	N.S.	–
DUI networks	0.0149	0.18	N.S.	–	0.5986	3.45	.001	–
Heteroskedasticity								
F	0.0350	13.55	<.001	–	0.0038	2.30	.022	–
F^2	-0.0001	-8.29	<.001	–	-0.0001	-2.60	.009	–
V-F	0.0012	3.03	.002	–	0.0014	3.51	.000	–
SD	2.0991	13.95	<.001	–	2.8999	0.364	.796	–

[a]Predicted value at mean for ecological measures; cognitive social measures centered at zero. [b]Exposure related to drinking frequencies or frequencies of driving within 4 hours of drinking.
*p < .05 two-tailed tests reported.

risks), ethnic groups (χ^2 = 13.94, p = .008; Whites with greater risks), age groups (χ^2 = 11.03, p = .012; greatest risks among persons 46–59 years old), income (χ^2 = 10.31, p = .016; increasing risks over income levels), marital status (χ^2 = 6.98, p = .030; greatest risks among single respondents, least among married respondents), and immigrant status (-0.513, z = -2.68, p = .007; persons born in the United States having greater risks).

As shown in the right-hand side of the table, the analysis of AID was dominated by exposure effects related to DAD. Net of these, neither drinking contexts nor heavier drinking in those contexts (Table 2) were significant. Only membership in DUI networks was related to greater risks for AID (one z-score unit related to 0.60 more events). Significant demographic correlates (not shown) included age groups (χ^2 = 14.17, p = .003; greatest among those under 30 years of age, decreasing with age), education (χ^2 = 14.42, p = .001; greatest among those with a high school education or less, decreasing with higher education), and marital status (χ^2 = 7.68, p = .022; greatest among single, least among married respondents).

Extrapolated impacts

We summarize the population impacts of the effects reported in Table 3 by applying them to a typical California city of 100,000 adults with average sociodemographic characteristics of those in the current study. This average city will have 53,140 drinkers who drink on 1,659,562 occasions every 6 months, 18,296 persons who drive after drinking over 6 months and produce 114,218 DAD events, and 1,476 persons with AID who produce 2,976 AID events. Noting that all these events originate after drinking some place, the first column lists the four places considered in Table 3 and the residual category of "other places."

The second and third columns present estimates of the frequencies of drinking in those contexts (from Table 1). The majority of drinking events take place at home (73%), with drinking at restaurants in second place (9%). (The percentages will not sum to 100% because the estimates are from different sources; total frequencies are from responses to drinking questions, drinking at different places from statistical estimates; the under coverage is about 4%.) Using parameter estimates derived from Table 3, columns 4 and 5 display the contributions of drinking places to DAD and AID (note again that values for "other places" are residuals). Drinking at restaurants is associated with the most DAD and AID events with drinking at bars in second place. Restaurants become a prominent source of risks because of their higher frequencies of use (1.7 times as often as bars). Finally, column 6 presents the numbers of drinking locations for each place in the average community (this cannot be estimated for parties and other places), and columns 7 and 8 present rates of DAD and AID associated with each location. Each bar is associated with far more DADs and AIDs than any other location.

An outline of the contributions of drinking places to rates of DAD is displayed in Figure 1. Conditional mean estimates from the censored regression model in Table 3 were plotted over marginal frequencies of drinking by drinking places;

TABLE 4. Crude impact analysis in a population of 100,000 adults 18 years of age and older over 6 months

Drinking context	Drinking events		Model-based contributions		Events per premise		
	Average per drinker	Population[a] incidence	Driving after drinking[b]	Driving after drinking too much[c]	Number of premises	Driving after drinking	Driving after drinking too much
Home	23.890	1,269,515 (73%)	15,411	428	18,683[d]	0.83	0.02
Bar	1.661	88,212 (5%)	26,097	726	15	1,739.80	48.40
Restaurant	2.851	151,449 (9%)	31,602	879	102	309.82	8.62
Party	1.710	90,869 (5%)	19,168	533	–[e]	–	–
Other places	2.793	59,517 (4%)	24,940	410	–[e]	–	–

[a]Percentages exclude other drinking contexts. [b]Estimate based upon independent contributions of drinking frequencies by contexts. [c]Estimate is proportional to driving after drinking exposures by contexts. [d]Estimates are based on 2009 Census estimates and outlet data for 50 cities; we assume that 53.14% of 35,185 Census defined households per 100,000 persons include one or more drinkers. [e]Number of premises at which parties take place cannot be ascertained.

each plot covers 97.5% of the frequency range for use of each place (frequencies of drinking at home ranged to 182 days and are right truncated). The figure also shows that greater drinking frequencies, regardless of place, are always related to greater rates of DAD; these range from very low for those who rarely drink up to 7.138 DAD events for daily drinkers. Because frequent drinkers drink more frequently outside the home, these drinkers will experience risk exposures related to these other drinking contexts (in order, restaurants, bars, and parties; Gruenewald et al., 2013). As shown in Table 4, the consequence of these shifts in drinking contexts is to shift risks toward drinking at restaurants, bars, and parties, with greatest numbers of DAD and AID events associated with restaurants but greatest throughput of DAD and AID events expected from bar locations.

Discussion

The results of these analyses show that risks for DAD and AID are broadly distributed in the drinking population and tied in different ways to different drinking places. Overall, a very large number of DAD and AID events are to be expected for any small community of 100,000 persons in California over a 6-month period. And, not surprisingly, drinking in the home appears to be related to lower rates of DAD whereas drinking outside the home was related to greater rates of DAD, with both leading to proportionately lower and higher rates of AID, respectively. However, quite surprisingly, conditional upon rates of DAD, rates of AID were observed to be unrelated to either drinking places or most measured cognitive-social characteristics (Tables 2 and 3).

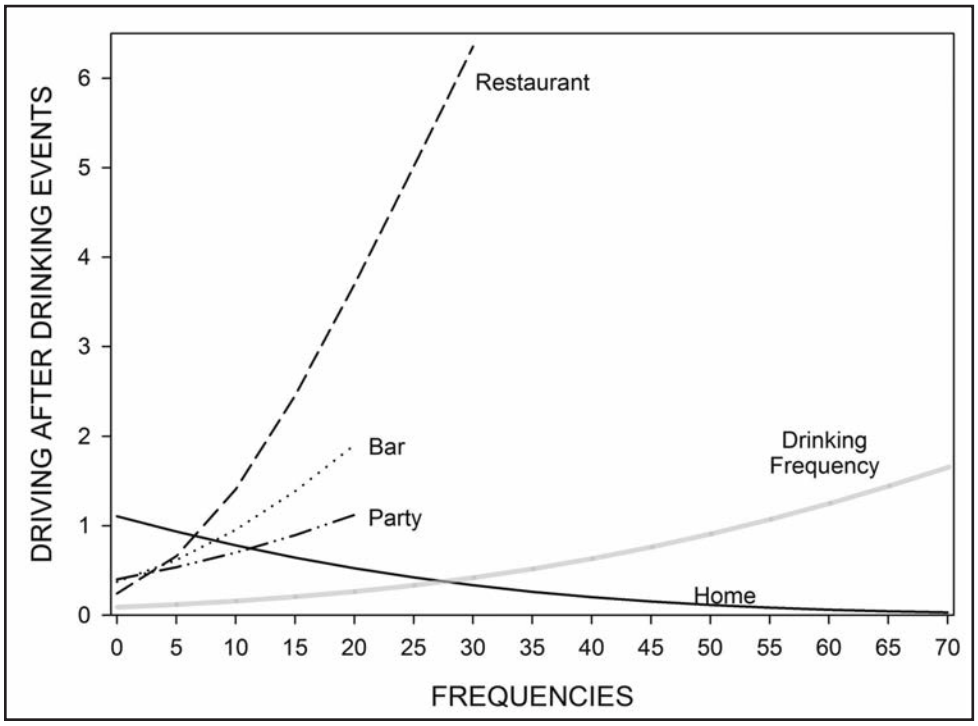

FIGURE 1. Marginal contributions of drinking contexts to risks for driving after drinking (DAD). Conditional mean estimates from the censored regression model in Table 3 plotted over marginal frequencies of drinking by drinking places; each plot covers 97.5% of the frequency range for use of each place (frequencies of drinking at home ranged to 182 days and are right truncated).

Rates of AID were directly proportional to rates of DAD, regardless of context, with some small effects associated with membership in DUI networks. Thus, the results indicate the degree to which use of drinking place may mediate relationships between well-known cognitive-social characteristics related to DAD and AID (impulsivity, tolerance of deviance, risky driving) and incidents of DAD and AID themselves. Although the results in Table 3 suggest very limited roles of these measures in predicting AID directly, risky driving remains a substantive predictor of DAD (itself a substantive correlate of AID) and, quite critically, as discussed in the introduction, cognitive-social measures are related to choices of places to drink outside the home (Gruenewald & Remer, 2013). Consequently, unlike the state-specific choices of drinking contexts that underlie rates of DAD and AID, trait-like cognitive-social characteristics affect several stages of the choice processes leading to these risk behaviors.

The results of this study continue to support the common conviction that drinking at bars presents considerable risks for DAD and AID. Because persons who drink at bars have been observed to drink more heavily and have cognitive-social characteristics related to both problem alcohol use and AID (Gruenewald & Remer, 2013), and these drinkers are at risk for alcohol dependence (Furr-Holden et al., 2011), it may be expected that bars may be a key context in which dependent drinkers experience AID risks. But the results also suggest that drinking at restaurants may contribute as much if not more to DAD and AID events because drinking takes place much more often in this context. Although these risks are diffuse, spread across many more drinking locations, they remain problematic. Similarly, many DAD and AID events appear to be associated with drinking in one's own home, at parties and other places like other person's homes (59,519 events every 6 months in a city of 100,000 persons; Table 4). Thus, DAD and AID events may also be diffusely distributed across residential areas, an observation that coincides with place-of-last-drink, studies which indicate that approximately half the number of persons arrested for drunken driving were drinking in a private residence before their arrest (Gruenewald et al., 1999; Padilla & Morrissey, 1993; Robinson et al., 2005).

Future directions

This study provides cross-sectional model-based estimates of relationships between drinking in different contexts and two self-report measures of DAD and AID. As such, certainly, temporally ordered data will be required to validate and extend predictions from the current analyses. But the most critical limitations of the current work are the very limited number of contexts considered in the analysis, the absence of specific data on drinking events that directly lead to DAD and AID in those contexts, and the possible misattribution of risks to contexts that overlap substantially in time. Drinking at home and in every other context will tend to overlap, and preloading at home may be associated with use outside the home. Thus, there is a great need for more detailed macro and micro social ecological studies of the roles of drinking contexts in drinking problems in community settings (Freisthler et al., 2014). Other limitations include limited validity of self-report DAD and AID measures leading to underreporting of DAD and AID rates, the subjective nature of self-reported AID measures in which assessments of drinking "too much" to drive safely may be confounded by personal characteristics of respondents, biases because of telescoping across the different time frames over which data were acquired (28 days, 6 months, and 1 year), the possibility that the average durations of drinking events across persons may partially confound estimates of dose-response effects, and, finally, that the contexts of use reported for residents of California may not generalize to drinking contexts and regulatory systems outside the state.

These limitations remain of essential importance to future work. But the results of this study do, nevertheless, strongly suggest new environmental preventive interventions to reduce alcohol-impaired driving: If much of the variance in rates of DAD and AID are explained by the selection and use of drinking contexts, and once those contexts are selected likelihoods of DAD and AID are relatively fixed, then individual prevention efforts might focus on the selection of drinking contexts as a protective behavioral strategy to reduce drinking and drunken driving. Proportional reductions in the use of bars and restaurants may have a disproportional impact on AID as drinkers shift routine drinking activities away from high- toward low-risk venues. This could lead to greater diffuse risks related to drinking in the home, an observation supported by spatial population analyses demonstrating elevated risks for alcohol-related motor vehicle crashes in residential areas (Levine & Canter, 2011), but it also suggests that prevention and enforcement programs aimed at reducing driving after drinking in the home; in the homes of friends, relatives, and others; and on occasions when parties take place in the home, are critically needed.

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